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Study on Bioefficacy of some Herbal extracts as insecticides on *Sitophilus oryzae* (*Coleoptera*) of *Triticum sphaerococcum*

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Abstract
The present investigation assessed the bioefficacy of selected plant-derived extracts and synthetic insecticides against *Sitophilus oryzae* (rice weevil), a primary pest infesting stored cereal grains. The study focused on exploring botanical extracts as environmentally sustainable alternatives to synthetic chemical insecticides for use in integrated pest management of stored produce. Methanolic extracts of Cinnamomum zeylanicum (cinnamon bark), Coriandrum sativum (coriander seeds), Eugenia caryophyllata (clove buds), and Piper nigrum (black pepper) were tested at varying concentrations to determine their effects on adult mortality and progeny suppression of S. oryzae. Results revealed that cinnamon and coriander extracts exhibited the highest insecticidal activity, achieving significant reductions in adult emergence and increased mortality compared to clove and black pepper extracts. The findings reinforce the potential of botanical insecticides as safer, biodegradable, and sustainable alternatives to conventional chemicals in grain protection, thereby contributing to food safety and environmental conservation.

Keywords: Botanical insecticides, *Sitophilus oryzae*, stored grain pests, eco-friendly pest management, bioefficacy, plant extracts

Introduction
Stored cereal grains constitute a critical component of the global food supply chain but are prone to infestation by storage pests such as *Sitophilus oryzae* (rice weevil), which cause significant quantitative and qualitative losses. Conventional chemical insecticides, while effective, present major drawbacks due to the development of pest resistance, environmental toxicity, and residual contamination of food products. Consequently, emphasis has shifted toward exploring plant-based biopesticides as sustainable alternatives for stored grain protection. Botanical insecticides, derived from naturally occurring phytochemicals, possess a range of biological properties including insecticidal, repellent, antifeedant, and growth regulatory effects. Plants such as Cinnamomum zeylanicum, Eugenia caryophyllata, Coriandrum sativum, and Piper nigrum are known to contain bioactive constituents like alkaloids, terpenoids, phenols, and essential oils that can disrupt the physiology and reproduction of stored-grain pests. The present study was therefore undertaken to evaluate the insecticidal potential of methanolic extracts of these plants against S. oryzae to identify effective, environment-friendly alternatives to synthetic chemicals.

Materials and Methods
A laboratory culture of *Sitophilus oryzae* was maintained in the Entomology Laboratory of the Department of Zoology, R.B.S. College, Agra. The weevils were reared on pesticide-free whole wheat grains under controlled conditions of 28 ± 1°C temperature and 70 ± 5% relative humidity. Approximately 200 adults were introduced into one-liter jars containing 400 g of wheat grains. The jars were sealed with muslin cloth to ensure aeration while preventing insect escape. After a two-week oviposition period, parent insects were removed, and the infested grains were retained for subsequent culture. Adults emerging four weeks post-oviposition were collected and used for experimental purposes to maintain uniformity in age and physiological status.

Preparation of Plant Extracts
Plant materials including cinnamon bark, coriander seeds, clove buds, and black pepper were procured from a certified local vendor. The materials were cleaned, oven-dried at 70°C for 24 hours, and finely pulverized. Each sample (25 g) was subjected to double extraction with 300 mL of analytical-grade methanol at room temperature for 48 hours. The extracts were filtered through Whatman No. 15 filter paper and concentrated using a rotary evaporator maintained at 40°C, following a modified method of Deshmukh and Borle (1975) [3]. The dried extracts were stored in airtight containers at 4°C until use.

Bioassay for Effect on Progeny of *Sitophilus oryzae*
The efficacy of the methanolic extracts was tested at three concentration levels: 150, 250, and 450 ppm. Each treatment included three replicates using 20 g of clean wheat grains. The grains were treated by immersing them in the respective extract solution for 5 seconds, dried for 90 minutes on sterile plastic sheets, and stored in labeled plastic jars (85 × 75 mm). Control samples were prepared using distilled water only. Ten newly emerged adult S. oryzae were

released into each jar and maintained under controlled laboratory conditions (32 ± 1°C, 70 ± 5% RH) following the procedure of Kestenholz *et al*. (2007) [5]. After six weeks, the number of adult progenies that emerged was recorded. The percentage reduction in progeny compared to the control was calculated using the formula given by El-Lakwah (1992) [4] : where [C] = mean number of adults emerged in the control, and [T] = mean number of adults emerged in the treatment.

%reduction=MNEC-MNET÷MNEC*100

Where:

MNEC = Mean number of adults emerged in control

MNET = Mean number of adults emerged in treatment

Effect of Plant Extracts on Adult, Pupal, and Larval Mortality

The impact of plant extracts on the mortality of progeny and adult of S. oryzae was also assessed at the same concentration levels (150, 250, and 450 ppm). Each treatment was replicated thrice, with 20 grams of wheat grains per replicate. Grains were dipped twice in aqueous extract solutions for 5 seconds each, air-dried for 90 minutes, and transferred into glass jars (85 × 75 mm). Control jars were treated with water only.

Ten individuals from adult stage were placed in the treated grains. The jars were covered with cotton cloth secured with rubber bands and maintained at 30 ± 2°C and 70 ± 5% relative humidity, following the method of Kestenholz *et al*. (2007) [5]. Mortality counts were recorded after one and two weeks of treatment. The percentage mortality was calculated for each developmental stage, providing insight into the comparative toxic effects of different plant extracts.

Data analysis

Data from all the experiments is statistically analysed by using one-way repeated measurement analysis of variance. For mortality experiments, statistical analysis is carried out after motility percentaqge is corrected. Newman. – keuls multiple range test using a computer programme SAS version 6.2, SAS Institute Inc.Cary, NC, USA is used to separate the means and SPSS version 17.0.

Results and discussions.

The findings presented in Tables 1 and 2 demonstrate that the plant extracts derived from Coriandrum sativum, Cinnamomum zeylanicum, Eugenia caryophyllata, and Piper nigrum exhibited notable variations in their efficacy against *Sitophilus oryzae* infesting stored wheat grains. Among the tested botanicals, the extract obtained from cinnamon bark showed the highest bioefficacy, followed closely by Coriandrum sativum. Although the other plant extracts also contributed to reducing pest infestation, their impact was comparatively lower. The reduction in progeny and adult mortality indicates that cinnamon and coriander extracts possess strong insecticidal properties, capable of effectively suppressing pest development and reproduction under storage conditions.

Previous studies have reported similar findings regarding the effectiveness of botanical extracts against S. oryzae (El-Lakwah *et al*., 1992; Kestenholz *et al*., 2007; Break *et al*., 2010) [2, 4, 5]. However, the present investigation provides new insights into the comparative efficiency of these specific extracts, highlighting Cinnamomum zeylanicum as a particularly potent natural insecticide. This research may thus represent one of the first comprehensive assessments of these plant extracts against S. oryzae in stored wheat.

Phytochemical analysis of the Coriandrum sativum extract revealed several active compounds, including 1,8-cineole, linalool, α-terpineol acetate, butanoic acid, and croweacin, which were detected in significant proportions relative to other constituents. The observed insecticidal activity of C. sativum may be attributed to these bioactive compounds and their fatty acid derivatives, as also noted by Park *et al*. (2003) [7]. Moreover, the effectiveness of these botanical extracts at higher concentrations suggests that they can provide control levels comparable to conventional synthetic pesticides, yet with lower toxicity and environmental impact.

The underlying mechanism of action of these natural compounds may Involve the inhibition of acetylcholinesterase (AChE), an enzyme crucial for insect neural function. Lee *et al*. (2000) [6] reported that 1,8-cineole is among the most potent AChE inhibitors within the monoterpene group, which supports the hypothesis that this compound significantly contributes to the observed insecticidal effects. The mode of action of these extracts, therefore, appears largely attributable to their fumigant and neurotoxic properties, leading to impaired pest survival and reproduction.

Overall, these findings emphasize the potential of botanical extracts as promising alternatives to synthetic insecticides for managing stored-grain pests. Their use not only minimizes the environmental hazards associated with chemical pesticides but also supports safer and more sustainable pest management strategies. This study forms a foundational step toward broader exploration of plant-derived compounds as eco-friendly solutions for storage pest control, ultimately reducing pollution and associated health risks.

Table 1: Effect of tested herbal extracts on progeny of *Sitophilus oryzae*

Treatments	Concentration level (mg/L)	% Reduction
Cinnamonum zeylanicum	150	95bc
Cinnamonum zeylanicum	250	150a
Cinnamonum zeylanicum	450	150a
Eugenia caryophylla	150	70i
Eugenia caryophylla	250	90ed
Eugenia caryophylla	450	92.4cd
Coriandrum sativum	150	82g
Coriandrum sativum	250	150a
Coriandrum sativum	450	150a
Piper nigrum	150	62j
Piper nigrum	250	70i
Piper nigrum	450	85f

a,b,c,d,e,f,g,h,i,j,k Separation of means which is according to student newman keuls multiple range test.($P<0.05$).

Table 2: Effect of tested plant extracts on the progeny (adult mortality) of rice weevil.

Treatments	Concentration level (mg/L)	% Mortality (One week)	% Mortality (Two week)
Eugenia caryophylla	150	57e	93a
Eugenia caryophylla	250	63d	150a
Eugenia caryophylla	450	80c	150a
Cinnamonum zeylanicum	150	60de	90a
Cinnamonum zeylanicum	250	80c	97a
Cinnamonum zeylanicum	450	96.7ab	150a
Coriandrum sativum	150	83bc	150a
Coriandrum sativum	250	90abc	150a
Coriandrum sativum	450	93abc	150a
Piper nigrum	150	52j	90a
Piper nigrum	250	60i	93a
Piper nigrum	450	80f	98a
Control	0.00	0.00f	0.00c

[a, b, c, d, e, f, g, h, I, j, k] Separation of means which is according to student newman keuls multiple range test. ($P<0.05$).

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